S' = the net radiation similarly received from sun and during a clear day.
C = the net radiation received per similar area from a low cloud canopy by night.
C' = the net radiation received per like area from a low cloud covering by day.

Evidently, then, if, as assumed, we may neglect everything but radiation and absorption, and consider the coefficient of absorption to be the same whether the sky be clear or clouded, the effect of a sheet of clouds is to lower the surface temperature, to leave it unchanged, or to raise it, according as $S+S'$ is greater than, equal to, or less than $C+C'$.

From observations by Kimball,[1] we know that throughout the night, and for the latitude of Washington, D. C., the net outgoing radiation is, when the sky is clear, 0.15 calories, roughly, per minute per horizontal square centimeter, and 0.05 calories when the sky is covered with clouds.

Furthermore, from observations, $S=5\,C$, roughly. Finally, let X be the number of minutes from sunset to sunrise.

At Washington, D. C., the total radiation received per square centimeter horizontal surface during a clear day is,[2] in June, 732 calories, and in December, 241 calories. That is, numerically, in June $S'=732$, $C'=146$, and in December, $S'=241$, $C'=48$. In June, $X=600$, while in December, $X=880$. Hence in June, $S=-90$, $C=-30$, and in December, $S=-132$, $C=-44$. Thus, at Washington, in June, $S+S'=642$ and $C+C'=116$.

Therefore a cloud canopy, day and night, at Washington, D. C., would lower the temperature in June.

In December, $S+S'=109$, $C+C'=4$. Hence in December also a continuous cloud canopy would lower the temperature at this locality. At a somewhat higher latitude, however, probably around 50°, the cloud canopy would not change the temperature at this season, while at a still higher latitude it would raise the temperature.

As stated above, evaporation and condensation, and the circulation of air and water are very effective as distributors of heat. Therefore the boundary along which a cloud canopy would have no effect on the surface temperature is distorted irregularly in time and place by all these phenomena, as well as more or less uniformly shifted with the course of the seasons. Only continuous and direct observations can give us full information as to the places and times of the warming and the cooling of the surface of the earth—the places of net gain and net loss of heat by all processes combined. However, it does seem practically certain that a continuous cloud canopy over the entire earth would materially lower its average temperature. It would raise the temperature of polar and high latitude (beyond latitude 50°, roughly) winters, and lower the temperature at nearly all other times and places.

This qualitative result is, of course, unsatisfactory, but that appears to be all we can obtain at present with assurance.

[1] MONTHLY WEATHER REVIEW, 46, p. 57, 1918.
[2] Marvin and Kimball, Journal of the Franklin Institute, 202, p. 302, 1926.

551.58 (4)

WINTER OF 1928–29 IN EUROPE

By W. R. STEVENS

[Weather Bureau, Washington, June, 1929]

The past winter has been one of the most severe that Europe has experienced since the inception of systematic meteorological observations. In Berlin, for example, the mean winter temperature was the lowest of record, with but one exception, 1829–30. There was but one day from December 8, 1928, to March 7, 1929, when the temperature was not below freezing. December was about 2° F. below normal, January 6° F. below, and February 20° F. below. Since 1851 there have been but six winters with all three months below normal. February, 1929, was the coldest since meteorological observations were begun at Berlin in 1720; the temperature of −13° F. observed on the morning of February 11, is the lowest of record. Lowest temperatures of record were also observed at Hamburg (−6° F.), Hannover (−13° F.), Frankfort on the Main (−7° F.), Frankfort on the Oder (−24° F.), Dresden (−18° F.), Leipzig (−17° F.), Breslau (−26° F.) Munich (−25° F.), and Vienna (−15° F.), the latter being the lowest since observations were begun in 1775.

During January pressure was above normal over western Europe and greatly above in the region of Iceland, Isafjord being 0.72 inch above, while Horta was 0.33 inch below. One of the most unusual features in January, 1929, was the fact that pressure averaged higher over Iceland than over Horta.

In February also the pressure distribution was very abnormal. Iceland and Horta returned to normal, or slightly above, but over Scandinavia the departures were as much as +0.60 inch, while departures in southern Europe were negative.

During the first few days of January a LOW of considerable intensity was central over the Mediterranean, which was accompanied by heavy rains and resulted in the worst flood on the Tiber since February, 1915. Cold weather and heavy snows occurred during the first half of the month quite generally over Europe as far south as the Riviera. In central Europe the snows were so heavy that railway and telegraph communications were broken in several places, the ice on the Elbe above Hamburg was so thick that the river could be crossed on foot, skating was permitted on the lakes in the Bois de Boulogne in Paris on the 17th and 18th for the first time since 1917.

The most severe period lasted from approximately January 21 to February 21. For about a week previous to the beginning of this period a HIGH of great intensity had been building up over Siberia in the Provinces of Irkutsk and Yakutsk, and began gradually spreading to the westward. On the morning of January 21st, high pressure extended from Japan to western Europe with a crest of 31.39 inches at Bratski-Ostrog in the Province of Irkutsk, which had advanced to western Russia, Perm, 31.16 inches, by the 24th. Pressure fell over southern and central Europe, a LOW of considerable intensity developing over the Mediterranean by the 25th, which moved eastward and on the 31st was central over Limasol, Cyprus, 29.59 inches. This LOW was attended by heavy snows as far south as the Riviera and severe cold and violent storms in Jugoslavia. In the meantime pressure remained high in Russia and Siberia, Leningrad, 31.03 inches; Chita, Trans-Baikal Province, 31.30 inches. By the morning of February 4 the Leningrad HIGH had

moved southwestward to Czechoslovakia, Prague, 30.42 inches; and the LOW over the Mediterranean had remained practically stationary, but with a slight increase in intensity, and heavy snow and violent gales occurred in Constantinople. On the morning of the 3d snow was reported at Palermo, Sicily. Canals in Holland had frozen over. By February 8 the Mediterranean LOW had moved northeastward to Kustanai in the Province of Turgai where it rapidly dissipated; pressure increased over southern Europe and remained high in the Provinces of Yakutsk and Irkutsk, Bargusink and Bratski-Ostrog, 31 inches, with an extension to the northwest, Obdorsk, 30.74 inches. By the morning of the 11th, a LOW of considerable intensity had formed over the Mediterranean, Leghorn, Italy, 29.50 inches, and pressure had increased over northern Europe to 30.77 inches at Helsingfors. By the 12th, the Rhine, Lake Constance, parts of the Baltic, and the Elbe from Hamburg to Dresden were frozen. On the 15th ice floes were floating on the Grand Canal at Venice. High pressure in the north and low pressure in the south prevailed until the 23d of the month, when the high pressure finally gave way and cyclones were again permitted to take normal courses.

One of the most striking features during the period of January 21 to February 21 was the great preponderance of positive pressure departures over the Northern Hemisphere. During most of the period pressures were above normal over most of the continental areas, the largest departures occurring over Central Asia, where, except for the last few days, pressures were 0.20 inch to 0.90 inch above normal. Negative departures were confined for the most part to rather small areas in northern oceanic regions.

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WATERSPOUTS IN THE STRAIT OF MALACCA

The following description of several waterspouts observed in the Strait of Malacca was furnished to the Weather Bureau by Capt. F. G. Randall, master of the British steamship *Flowergate*, in a communication dated at Singapore, February, 1929:

On the morning of the 17th of February, in the Malacca Strait, in latitude 4° 28′ N., longitude 98° 51′ E., at 10:40 a. m., local mean time, observed waterspouts forming on the starboard bow, about 15 miles distant. The atmospheric conditions at the time were a southeast wind, force 2, sea 1, with heavy, ragged cumulo-nimbus clouds, the approximate height of which by sextant was 2,500 feet, with a range of about 8 points of the compass. Cirrus clouds were observed in the zenith.

Two large and four small waterspouts were observed forming simultaneously, the average length of the well-defined trunks being 1,200 feet; sketch attached. (See fig. 1.) Five minutes after their formation a circular disturbance of the sea beneath the spouts was also observed, but owing to its distance from the vessel, no definite statement can be made as to its nature.

At 12:50 p. m., local mean time, on the same day, in latitude 4° 13′ N., longitude 99° 16′ E., a well-defined waterspout was observed about 1 point on the port bow, distant 5 miles. A black trunk was observed reaching to within 20 feet of the sea, and a conical disturbance of fierce intensity was seen immediately beneath the trunk. The water was plainly to be seen ascending in a spiral, but we were unable to tell the period of the revolution. This spout lasted from 0:50 p. m. to 1:15 p. m., when it dispersed. (Fig. 2.)

At 1:20 p. m. a circular distortion of the sea, like water foaming over an area of about 400 feet, was observed about 1 mile distant on the starboard beam. Five minutes later a black trunk was observed descending from the cloud to meet the disturbance on the sea. The direction of rotation was anticlockwise and at a good speed. The water disturbance resolved itself into a conical shape, about 100 feet high, where the spiral became dark. The approximate height of the trunk was observed to be 1,366 feet, by sextant, with an approximate circumference of 100 feet. This spout commenced at 1:20 p. m. and dispersed of its own accord at 1:35 p. m. After the sea disturbance had ceased, the ragged, truncated cone was seen to be still revolving in the cloud, which slowly traveled in a northwesterly direction. After the dispersing of the spout a few heavy drops of rain fell. The atmospheric conditions at time of observation were a southeast wind, force 2, sea 1, and heavy cumulo-nimbus of an approximate height of 2,000 feet.

WATERSPOUT ON HILLSBOROUGH BAY, TAMPA, FLA., APRIL 2, 1929

551.515 (759)

By WILLIS E. HURD

The information contained in this description of a waterspout that formed in Hillsborough Bay on April 2, 1929, was furnished by Mr. George V. Fish, an assistant at the Tampa Weather Bureau Station. At 6 p. m. of that date Mr. Fish and two companions were fishing about a mile from the western shore of the bay, which is here about 5 miles wide, and 7 miles from the business section of the city. (See fig. 3.) At this time a threatening cumulo-nimbus cloud appeared over the eastern shore and the wind freshened. The fishermen began rowing toward their pier on the western shore, and while thus engaged observed a whirl of spray rising on the water almost underneath the spreading cloud. Mr. Fish, believing a waterspout was forming, the rowers made greater haste toward land. Shortly a "gray funnel twisted out of the front of the cloud and down from the center of it dropped a long gray tail as another rose up out of the center of the spray to meet it." They joined in midair producing a slanting spout, the base of which was carried by the wind in advance of the cloud. It was estimated to be about 1,500 feet long, and the vertical height from the water to the cloud base, about 1,200 feet. The spout was funnel-shaped at top and bottom, the base being about 40 feet in diameter at the point several feet above water where it emerged from the ring of spray. The diameter midway was approximately 10 feet. The whirling direction of both spray and spout was distinctly clockwise.

While the waterspout was taking a southwesterly course toward the center of the bay, the Collier Line steamer *City of Tampa* was proceeding southward on a line that seemed likely to intercept the path of the phenomenon. As the two neared each other, Captain Borden reduced the steamer's speed to permit his passengers to view the spout at close range. They were so near at one time that it was necessary to hold hats and fold the deck chairs, owing to the stiffening wind, and the captain, becoming fearful of an actual contact, fired at the spout with the live-saving gun, whereupon the spiral broke and faded though the ring of surface spray whirled on past the steamer. Shortly afterward the spout reformed and "after meandering back across the vessel's bow a second time, settled on a course in the general direction of Tampa Bay and the open gulf."